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ABSTRACT

Described is a course designed for engineering science and natural science freshmen and open to upperclass nonscience majors entitled "Science of Modern Materials" and which has been successfully presented for several years. This paper presents the philosophy behind the course, the teaching methods employed, and the content of the course. The course has a large scope, starting with water and the decomposition of igneous earths, including wood and wood products, cements, stones, vitrified products, metals and alloys glasses, plastics, semiconductors, and ending with ecological problems originated by materials generated pollution. The relation of structure and property is the theme followed through all but the ecology part of the course. This course attempts to intrigue the nonscience major by showing him how he lives with and depends on materials and how he or his representative will be responsible for laws regulating these materials in the future. In the final exam, the student must decide between several materials from which to erect a pole on his property on the basis of the ecological damage of maintaining the pole. The syllabus of the course indicates the demonstrations and teaching aids that were used. (LS)

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DEPARTMENT OF MECHANICS
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INTRIGUING FRESHMEN WITH MATERIALS SCIENCE

by

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Abstract

A course designed for physical science and engineering majors and open to upper classmen in other areas is entitled "Science of Modern Materials" and has been successfully presented for four years. The course has a large scope, starting with water and the decomposition of igneous earths, going through wood and wood products, cements, stones, vitrified products, metals and alloys, glasses, plastics, semi-conductors, and ending with ecological problems originated by materials generated pollution.

The relation of structure and property is the theme followed through all but the ecology part of the course. The "intrigue" is provided by making the student cognizant of his involvement with materials. This is illustrated by the final exam wherein the student is given an acre of land on which a utility pole is to be erected and on which all the ecological damage of generating and maintaining the pole will occur. Since the decision he makes will affect his welfare, he is confronted with the necessity of understanding materials in order to live better.

The syllabus of the course is presented and several examples of the "intrigue device" are related.

INTRIGUING FRESHMEN WITH MATERIALS SCIENCE

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Introduction

A course entitled "The Science of Modern Materials" was introduced four years ago under the following advertisement:

"50.11-12(E,N,S) The Science of Modern Materials

This course offers an introduction to modern materials on an elementary level. Both metals and nonmetals are considered and the liquid, solid, and gaseous states are examined. The methods of classifying materials and studying their structure and reaction to mechanical, chemical, optical, and electrical stimuli are introduced. An important part of the course is that the relevance of each topic introduced will be illustrated by showing the necessity of understanding the topic in the everyday world of engineering synthesis and design, manufacture, and ecology. Limited to engineering science and natural science freshmen and to upperclass nonscience majors."

The course has been popular and has experienced growing enrollments each year. The purpose of this paper is to illustrate the philosophy behind the course, the teaching methods employed, and the content of the course.

Philosophy Behind the Course

The art of manipulating and using materials is one which certainly was generated in past ages although the science of materials is a relatively new pursuit. To ignore this art is to ignore one of our most wonderful heritages and slights an interest which is probably common to all people regardless of their level of sophistication. If the purpose of a course is to sharpen the interests of a neophyte in the field or to generate an interest in someone outside the field, then no better route can be found than through the portrayal of the art of using materials augmented by a scientific explanation of the phenomena involved.

An approach to teaching such a course could be to expose the student to the modern sophisticated theories and models which we use to understand our field. Although this approach may sharpen the interest of the "materials" neophyte, it would more than likely "turn off" the student in pre-law, pre-med, social relations, political economy, etc. It was deemed important in this course to intrigue the non-materials major. This can be simply done through the art approach by appealing to his ego and showing the student how he lives with and depends on materials every day and how he or his representative will be responsible for laws regulating these materials in the future. When the student recognizes that by better understanding the science of materials he can provide the influence to obtain better laws regulating environmental control he should become enthused regardless of his selected field of specialty.

The student's interest is captured by illustrating the art of manipulating and using materials as his forefathers did or as today's artisans do. The interest level is maintained by showing the student that he already has an appreciation for, if not considerable knowledge of, these arts. His continuing interest is stimulated by the scientific explanations of the phenomena involved in these arts.

Course Operation

This course meets for 1-1/4 hour sessions twice a week during the entire school year. The first meeting is used to define "modern materials" as those materials being currently used by our society. The illustration from "Materials" A Scientific American Book(1) that wood is, by weight or volume, the major material used today generally elicits surprise and acknowledgement that it must be considered a modern material. A classification system for materials is commenced at the first lecture when the student is asked to list as many natural (not manufactured) modern materials as he can. The questions are posed, "How do these natural materials (as well as the ores) occur and are they in equilibrium?", "How can they be transformed to render them most useful?"

To impress the students with the earth's development of materials the color-sound movie "Anthology of a Volcano"(2) is shown, as well as slides of lava flow fields and samples of various types of lava. It is at this point that the importance of material properties is made as the material water is introduced. Because water plays such an important role in the decomposition of the igneous rocks (and in subsequent lessons, in corrosion) time is spent looking at water as a solvent. The growth of mineral crystals by supersaturation, solubility variation as a function of dissolved CO_2, biochemical decay, and the role of aerobic and anareobic bacteria are introduced as are the concepts of surface tension and viscosity. The illustrative material used in the surface tension presentations are taken from "Soap Bubbles" by C. V. Boys(3). Although this entertaining treatise is a mine of illustrations, the principal one selected is Chichester Bell's water telephone for with this as a stepping stone, shot casting and free flight melt spinning can easily be understood in later presentations. The future of utilization of the surface tension property is illustrated by an explanation of the new printing system devised by Mead Corp.(4).

This illustration of the mixture of art and science suffices to show the technique used in the course. It is obvious that such a continued recitation will result in a superfluous presentation. The following tabulation fairly portrays the order of subjects presented, teaching aids used, and the time allotted to each area.

The students are given a test four times in the first semester and twice during the second semester. An examination is given at the end of each semester. Problems are assigned continuously during the year. The text used in the course is "A Textbook of Materials Technology" by L. VanVlack, Addison Wesley, 1973. Although the text is not used on an assignment basis, the student is told what portion of the text or what auxiliary reading he should have covered each week. Almost all of the problems are taken from the text.

Order of Topic Presentation	Demonstration	No. of Lectures	Teaching Aid
Water	Lava-Water Telephone-Shot Mfgr.	2	Anthology of a Volcano(2), Soap Bubbles(3)
Wood	X-sections of hard and soft wood	2	Engineering Materials, White(5)
Paper	Creped - Kraft-Bleached	2	Engineering Materials, White - Lit. from Scott Paper Co.
Plaster	Gypsum plaster - Lost Wax Casting(6)	2	Experience
Concrete	None	4	Van Vlack(7) Johnson's Matls. of Construction
Metals	Fun in Metals Movie(9)	8	Crystal models - varying grain size specimen
Alloys	Dilatometry	8	Bled dendrites - Cu-Zn Diagram with Specimen and Micros showing equilibrium and non-equilibrium - Art Recrystallization Sketching(10)
Corrosion	Season cracking test	1	Specimens of Failure by Corrosion
Crystallography	Plasticity of Metals (movie) (11) Dome projector	2	Single crystals galore
Dislocations	Bubble Model(12), Hersh, Horne Whelan movie(13)	3	Models
Ceramics	Toy extrusion of brick	4	Samples of various ceramics
Polymers	80/20 Gelatin mfg.	4	Polymer Chart(14)
Semiconductors		4	
Societal Problems		2	"Doomsday Syndrome" John Maddox(15)
Inventions	Melt Spinning, Peen Plating	2	Literature acquired from "Patent Office" (16)
Pollution		3	

It is very easy to arrange for plant visitations in the Baltimore area and 3 to 4 hour visits are arranged with such plants as Bethlehem Steel Co., Sparrows Point, American Hammered Piston Ring Div. of Koppers Co., Kennecott Copper, ASARCO, or Armco Steel.

In order to provide the best learning situation, the long term pursuit of definitions or testing procedures is avoided. This can be illustrated in the following way. Although normal stress - strain and shear stress - shear strain relations must be introduced early in the course, care is taken to introduce such relations during the first semester with a rather uniform dispersion and as needed with the material presented. For instance, shear stress, shear strain, viscosity, and surface tension are introduced in the discussions of water but modulus of elasticity, modulus of toughness, anisotropy, conductivity are introduced in the discussion of wood, and hardness, impact strength, and crystallization concepts are introduced in the discussion of plaster and concrete.

It is interesting to note that although it is not difficult to present the crystallography of the course by the standard classification and symmetry techniques, it is even easier to present this material if the student is "enthused" by showing him that he lives in a world virtually filled with crystals. This illustration is started in the discussions of the solidification of lava, carried through the plaster and concrete sections and amplified during the metal and alloy sections. Once the student is told that when he rides on a 727 jet aircraft he sails through the sky in a cocoon of metallic crystals numbering about 10^{12} he becomes interested in crystals. Once the student is shown that polycrystalline aggregates can have a crystalline texture just as wood has a fiber texture and that in both cases anisotropy results, he becomes interested in methods of parameterizing the anisotropy, he sees a reason for understanding Miller indices, and stereographic projection becomes a game worth learning. Due to the large volume of material covered, no real training is done in the crystallographic area but the basic principles are covered. For instance, no real exercise is given in stereographic projection but with the class demonstration the student is expected to be able to sketch several standard projections.

The class demonstration is carried out in the following manner: A clear plastic hemisphere three feet in diameter which has been lightly abraded on its inner surface to serve as a ground glass screen is used as the standard reference sphere and is clamped to the lecture table. A 2" x 2" x 2" hollow lucite cube with 1/4" walls is attached to a handle carrying a flashlight battery and the light bulb is situated in the center of the cube. Holes approximately 1/8" diameter are drilled in the center of cube edges, cube faces, and corners and the entire cube covered with masking tape with the exception of thin (1/8") lines which gird the cube as the various crystal zones. These lines which allow light to shine through are colored so that the cube zones, and the dodecahedral zones can be distinguished.

Holding the lighted cube in the center of the reference sphere causes the principal poles and zones of the cube to be projected onto the sphere. Not only does the student instantly see the crystal projection but he can be shown how different poles can be rotated to the center of the projection thereby illustrating different standard projections. Such a teaching aid enables the introduction of this subject in minutes instead of hours.

A considerable portion of class time during the second semester is spent on materials oriented societal problems. The value of improving materials is shown to affect the future availability of materials as well as instant improvement in our capabilities. The role of research in materials improvement is delineated and the materials research currently proceeding in the department is revealed and explained. The role of invention and patents in materials improvement is also delineated and examples of such improvement are demonstrated. Patent literature is exposed as a viable literature and the student is urged to include it in his resources. Interest in this area has been sufficient to cause a new course "Innovation in Materials" to be introduced during the past semester.

The second materials oriented societal problem included is that of pollution and pollution control through the proper selection of materials. The following problem is given as a term paper examination at the end of the 2nd semester.

"One of the advantages of being informed in the materials field is that one has a better appreciation of pollution problems. Environments are polluted by people and nature but <u>with materials</u>. To make this point more relevant and to show the difficulty of total analysis in such a problem area, the following exercise is suggested.

"Presume you live on a one-acre plot which has all the natural resources you might find anywhere. The water run-off from this acre is your water supply and it is collected and stored in an adjacent pond. So that natural damage can be appreciated, presume that all material will come from and be converted on the one acre. The problem is to choose the material which will least upset the ecology of your property.

"A utility pole 40 ft. high is to be erected on your property and a choice must be made between wood, steel and concrete as the structural material. For equivalent structural response the concrete pole will be 10" x 10" x 40' and contain eight 1/4" dia. steel reinforcing rods each 40' long; the wood pole will be 10" dia. x 40' made of coniferous wood; and the steel pole will be 12" x 12" hollow shell, 3/8" thick with .015" galvanized coating.

"In considering the ecological damage, some of the points to be examined include:

I Original natural damage

a) Scarring (beauty)

b) Biochemical upset

c) Depletion

II Natural damage from processing

a) Waste

b) Air pollution

1) thermal
2) particle
3) chemical

c) By-product production

1) particle
2) chemical

III Replacement time"

The student is given four weeks to write his paper which is due on the day of the examination.

The examination consists of a mock county commissioner's meeting to decide which material will be established in a code for future utility poles. The graduate student grader for the course is chairman of the meeting. The class is divided into four sections. One section serves as the commissioners and one of each of the remaining sections represents vested interest groups in wood, concrete and steel, respectively. The ensuing two to three hour struggle between these students is apt evidence that, regardless of their area of interest, they have become intrigued with materials.

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